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Lilje, Jonathan ; Mosler, Hans-Joachim ; Kessely, Hamit

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## Factors Determining Water Treatment Behavior for the Prevention of Cholera in Chad

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**Abstract.** Cholera is a well-known and feared disease in developing countries, and is linked to high rates of morbidity and mortality. Contaminated drinking water and the lack of sufficient treatment are two of the key causes of high transmission rates. This article presents a representative health survey performed in Chad to inform future intervention strategies in the prevention and control of cholera. To identify critical psychological factors for behavior change, structured household interviews were administered to  $N = 1,017$  primary caregivers, assessing their thoughts and attitudes toward household water treatment according to the Risk, Attitude, Norm, Ability, and Self-regulation model. The intervention potential for each factor was estimated by analyzing differences in means between groups of current performers and nonperformers of water treatment. Personal risk evaluation for diarrheal diseases and particularly for cholera was very low among the study population. Likewise, the perception of social norms was found to be rather unfavorable for water treatment behaviors. In addition, self-reported ability estimates (self-efficacy) revealed some potential for intervention. A mass radio campaign is proposed, using information and normative behavior change techniques, in combination with community meetings focused on targeting abilities and personal commitment to water treatment.

### INTRODUCTION

Diarrheal diseases are the second largest threat to children in developing countries, causing an estimated 700,000 deaths in children under the age of 5 years in 2011, and are a leading cause of deaths worldwide.<sup>1</sup> Globally, cholera is on the rise, with an estimated 3–5 million cholera cases and 100,000–120,000 deaths reported each year, and a potential 1.4 billion people living at risk in endemic countries.<sup>2</sup> The increase in cholera cases can be directly linked to the ever-increasing number of vulnerable people living in unsanitary conditions without access to safe drinking water and adequate sanitation and hygiene. According to data from 145 low- and middle-income settings, the highest risk for diarrheal diseases within the cluster of risk factors results from inadequate drinking water.<sup>3</sup>

Evidence on the positive effect of point-of-use treatment on water quality, and significant reductions in diarrheal diseases among its users, exists.<sup>4–11</sup> The usage of chlorine products has been described as one effective and easy-to-use means of water disinfection. Likewise, the protective effect of solar-disinfected water against cholera infections in small children has been shown and could serve as an alternative point-of-use treatment method.<sup>12</sup> These products are relatively inexpensive and usually locally producible.<sup>13</sup> Compared with other key hygiene domains, water treatment interventions have been found to be the most effective for the prevention of diarrheal diseases, and combinations with different intervention elements did not augment these effects.<sup>14,15</sup> Treatment at point of use is also seen as superior to treatment at other levels (e.g., the source) due to possible recontamination during the transport, storage, and consumption process.<sup>16,17</sup> Water quality interventions at point of use are thus considered elementary wherever access to safe water is not provided 24 hours a day.<sup>15</sup> The role of unsafe water as a risk factor and the effectiveness of water treatment have also been shown in the context of cholera epidemics.<sup>18,19</sup>

In their spatial analysis of risk factors, Sasaki and others<sup>11</sup> describe the risk for infection with cholera as a result of indi-

vidual hygiene behaviors in addition to environmental circumstances. In this sense, the application and continued usage of point-of-use water treatment technologies directly rely on the end user's behavior, wherever necessary infrastructural or environmental factors are given. The success of intervention campaigns therefore depends substantially on individual behavior changes. Substantial change in human behavior is always mediated through shifts in psychosocial factors that determine an individual's behavior, such as attitudes, normative beliefs, and perceived self-efficacy, regarding a specific behavior.<sup>20–24</sup>

To our knowledge, no structured assessment of psychological determinants for water treatment via chlorination has been conducted to identify crucial factors to address in the design of behavior change interventions, and we could not find any publications on similar approaches for the targeted region.

For the first time, a structured and representative survey on behavioral determinants for water treatment behavior was therefore applied to a region at high risk for cholera in Chad. Tailored intervention strategies for the promotion of these key drinking water, sanitation, and hygiene (WASH) behaviors can subsequently be designed based on these findings, addressing exactly those psychological factors that have been shown to be of high importance for the adoption and maintenance of water treatment behavior within a specific local population.

The RANAS (Risk, Attitude, Norms, Ability, and Self-regulation)<sup>22</sup> model has been especially developed for the prediction of health behaviors in developing countries and is based on several established psychological health-behavior theories (e.g., health belief model,<sup>25</sup> protection motivation theory,<sup>26</sup> theory of planned behavior,<sup>27</sup> and health action process approach<sup>28,29</sup>). The model depicts five distinct components or “factor blocks”<sup>22</sup> that should be considered for a comprehensive understanding of the psychological characteristics of a study population in determining a specific behavior.

**Risk component:** The risk factors address the individual's understanding and awareness of his or her personal vulnerability to, and the severity of, a disease.

**Attitude component:** Attitudinal factors address an individual's feelings, as well as convictions about costs and benefits of a specific behavior, such as perceived price, taste preferences

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in the case of chlorinated versus non-chlorinated water, and expectations about beneficial consequences of a behavior.

**Norm component:** Norm factors represent the perception of how common a behavior is experienced within the social network, how popular or unpopular it is considered to be seen, and the level of personal obligation to conform with it.

**Ability component:** Ability factors capture individuals' estimation of their own competence in executing a behavior, including its uptake, maintenance, and recovery from drawbacks.

**Self-regulation component:** Finally, self-regulation factors address the question of self-monitoring strategies for a continued use or application such as remembering and coping planning for dealing with existing barriers or arising difficulties that constitute hindrances from the execution of a specified behavior.

All five RANAS components with their respective individual factors have predictive quality for an individual's behavior and can therefore be used in the assessment of intervention potential (IP) for behavior changes concerning point-of-use water treatment.

Once the assessment of the current psychological state of a study population regarding key hygienic behaviors has been done, the RANAS model also depicts which type of behavior change technique (BCT) should subsequently be applied.<sup>30</sup> The application of this approach can thus guide toward evidence-based decision making on strategies for the design of behavior change campaigns in the promotion of water treatment behaviors.

In addition to psychosocial factors on the individual level, the Integrated Behavioral Model for Water, Sanitation, and Hygiene (IBM-WASH) calls for the inclusion of contextual (or environmental) and technological factors that can also influence an individual's behavior, especially in settings that lack basic infrastructure.<sup>31</sup> Therefore, technological characteristics and environmental specifications of study sites should be considered in the development of intervention strategies, for example, including information on water sources, prices, and access to treatment material or technologies.

The authors of "Recommendations from international consultants on WASH targets and indicators post-2015," demand that "disadvantaged groups must be identified" to meet the global target of reducing inequalities within populations concerning access to safe water and sanitation (update 2014).<sup>32</sup> Those groups often represent the poorest of the poor (the bottom quintile), and special attention should be paid to serving them.<sup>33</sup> Potentially disadvantaged subgroups should therefore also be identified regarding access to technology, as well as other (environmental) factors, prior to the design of interventions, to supply these groups with specially tailored or additional interventions aimed at reducing existing inequalities.

**The present study.** The present study is part of a larger program for the development of BCTs in the effort to sustainably prevent and control cholera, for adoption by governments and public health practitioners. Within this project, we plan to implement community-based cholera prevention activities, with a particular focus on behavior changes concerning household water treatment. The geographic focus is on communities in the Lake Chad Basin (see Figure 1) that have been repeatedly struck by cholera outbreaks within recent decades.<sup>34</sup> According to the World Health Organization (WHO), in 2010 and 2011, the entire region witnessed



FIGURE 1. Geographic layout of study sites (black dots) in south-western Chad bordering the extreme north region of Cameroon along the two river systems Chari and Logone within the Lake Chad basin.

dramatic episodes of cholera, reporting over 60,000 cases.<sup>2</sup> This region features the typical environmental factors for a high risk of cholera outbreaks in river areas: hot air and low rivers that foster the breeding of bacteria, with subsequent inundations during the rainy season that enhance the probability of contact between humans and contaminated water and cause a breakdown of sanitary infrastructure.<sup>35</sup>

The country of Chad is located in central Africa, with an area of 1,284,000 km<sup>2</sup> and a total population of 11,175,915. Accessibility to basic social services is hampered by illiteracy, poverty, sociocultural burdens, and the geographic environment. According to the national demographic and health survey from 2004, health indicators show that the main causes of consultations at health facilities are malaria, acute respiratory infections, diarrhea, dermatitis, and trauma. Rates of access to drinking water and sanitation on the national level were 51% and 11%, respectively, in 2012; however, these averages mask important differences across regions and the majority of the population (88%) do not have improved latrines.<sup>36,37</sup> These precarious conditions are related to access to safe drinking water, sanitation, and hygiene, and are important risk factors for high rates of morbidity and mortality.

The present survey's goal was to assess psychological determinants for point-of-use water treatment in the local populations of several communities in Chad along the Chari and Logone rivers. We present findings addressing the following

research questions and propose adequate BCTs for the design of an intervention campaign.

- What is the current situation concerning water treatment behavior in households and are there important environmental or technological factors influencing water treatment behavior in Chad?
- What are the psychological determinants for the promotion of water treatment at the household level and how should they be addressed in interventions?
- Can subgroups of people or disadvantaged groups be identified on the basis of differences in environmental/technological, socioeconomic, and/or psychological factors?

## METHODS AND MATERIALS

Standardized structured questionnaires were administered in face-to-face interviews at 1,017 households split by location as depicted in Table 1 by a team of local interviewers recruited from the staff of the in-country nongovernmental research institution Centre de Support en Santé Internationale (CSSI), most of whom had prior experience of participating in studies and carrying out interviews. The research team went through a full-week training program that included briefings on the general project objectives, theory, and application of the measurement procedure, and instruction in practical implementation skills on the ground such as introducing oneself to a household and asking for their participation. Training also included simulations and two full days of field work in a non-study area that also served for testing the research instruments and application procedures.

The questionnaire was designed in French and completely translated into local Arabic by the whole team to guarantee shared understanding; special terms were also discussed together for cases where neither French nor Arabic was spoken in a household and local dialects had to be used. The application of the RANAS model approach was discussed with local experts, and the intelligibility of questions and rating scales were tested in focus-group discussions beforehand. The interview team was supervised by two additional superior staff members, as well as by the local and international researchers responsible throughout the whole process.

The interview covered questions on demographics and asked about water sources, current water treatment practices, and knowledge about water treatment technologies. Several

items were constructed for each psychological factor to address all of the RANAS components in detail.

**Eligibility criteria and choice of households.** The eligibility criteria for participating households were to have a child under the age of 5 years living within the household, and to provide informed consent to participate in the study. Interviewees were primary caregivers (women in 95% of cases), defined as the person responsible for household chores and childcare. Households were chosen randomly by the interviewers within the sites using a modified random-route procedure,<sup>38</sup> which involved being dropped off at different locations within the designated geographic-coverage area and then choosing a starting direction, addressing every third household along the way.

The study took place during two periods between December 2013 and May 2014 at a total of 10 study sites: Walia, Milezi, Diguel, and Chagua within the boundaries of Chad's capital, N'Djamena; Massaguet, about 150 km north of; Koundoul, Mandelia, and Logone Gana, in the district of Mandelia; and Guelendeng and Bongor, at a distance up to about 300 km south of N'Djamena along the Chari and Logone river systems feeding Lake Chad as shown in Figure 1 according to recommendations from the Ministry of Health.<sup>34</sup> This survey will later serve as a baseline for comparison of intervention-strategy effects on behavior in randomized controlled trials.

**Data analysis.** To determine data-driven intervention strategies targeting at important behavioral drivers, the IP for each psychological factor of the five RANAS model's components was estimated analyzing statistical means between groups of performers (Doers) and nonperformers (NonDoers) of water treatment. Total population means as well as differences in means (*t* tests) between the groups of Doers (people who currently *do* perform water treatment) and NonDoers (people who currently *do not* perform water treatment) were calculated for all psychological variables. According to the "Guideline for Behavior Change," the IP for psychological factor components and their subscales results from the distance of mean value to scale maximum.<sup>30</sup> For the present study, all factors falling at or below the mid 3-point value on a scale of 1–5 are considered important for the design of interventions, because of the remaining theoretical improvement reserve. In addition, differences between Doers and NonDoers of 0.5 points or more on the 5-point Likert scale will be addressed, representing a medium effect size referring to Cohen's notation.<sup>39</sup>

The IP is therefore calculated as a combination of the distance of the total mean from the desired scale maximum value (5-point scale end) as well as the difference between the group means. Analysis of variance tests were additionally run to confirm statistically significant differences in means between the groups of Doers and NonDoers for all five of the RANAS components. Values between 1 and 2 are considered as a low, 2–3 as a moderate, 3–4 as a high, and above 4 as a very high IP.

For the self-regulation component, groups of low-, mid-, and high-habitation Doers were compared, since questions about self-regulation cannot be answered by NonDoers. Subgroups were constructed according to primary water sources to identify any potentially disadvantaged groups showing major differences that could require special attention in an intervention campaign.

All calculations were computed using the IBM Corp. (Armonk, NY) SPSS Statistics software package.<sup>40</sup>

TABLE 1

Political regions of the study, number of interviews by Sub-Prefecture, and corresponding total population

Region	Sub-prefecture/zone of responsibility	Number of interviews	Total population (INSEED, 2009) <sup>45</sup>
Hadjer Lamis	Massaguet	78	52,776
City of N'Djamena	1 <sup>ère</sup> arrondissement (Milezi)	79	75,203
	8 <sup>ème</sup> arrondissement (Diguel et Chagua)	159	184,641
	9 <sup>ème</sup> arrondissement (Walia)	100	75,593
Chari-Baguirmi	Koundoul	83	38,871
	Mandelia	70	49,177
	Logone Gana	39	17,380
Mayo Kebbi Est	Guelendeng	163	37,242
	Bongor	246	69,787
Total		1,017	600,670



The study protocol was reviewed and approved by ethics committee boards at the University of Zurich, Switzerland, as well as by the responsible division of the Ministry of Health in Chad. Permission from local authorities had to be obtained for all individual study sites by informing the mayors, official chiefs of quarters and smaller living units, as well as religious leaders, especially in Muslim neighborhoods, by personal visits and by supplying them with copies of the in-country-approved study protocol. Verbal informed consent was obtained from all participating subjects due to high illiteracy in the study area.

## RESULTS

**Study population.** The mean age of the respondents was 31 years (standard deviation [SD] = 11.6) and the mean household size was 8.6 persons (SD = 5.3). On average, interviewed households possessed half (mean [M] = 0.52; SD = 0.26) of the eight items that were asked about (bed, table, electricity, radio, television, refrigerator, motorized vehicle, and phone) to generate a socioeconomic score (range: 0–1). Details on religion, education level, and literacy rates, as well as results from eight knowledge questions on water treatment, can be found in Table 2, with differences between the groups of Doers, NonDoers, and NonDoers using traditional wells.

To address the questions about current water treatment practices and factors determining their application, we asked about what the sources were for household drinking water, knowledge of methods to perform water treatment, and current self-reported water treatment practices. Primary water sources used for the supply of drinking water in the sample included mechanical or electric pumps from deep and protected wells (55.7%); private or public water taps (25.8%); traditional, unprotected, and shallow wells (5.8%); delivered water from water vendors (3.5%); and surface water such as lakes and rivers (3.4%) (Table 1). Over half (55%) of all inter-

TABLE 2

Characteristics of the study population, separate for the groups of Doers, NonDoers, and NonDoers with wells as the primary water source

	Means			
	Total	Doer	NonDoer	NonDoer (open wells)
Age	31.40	31.80	31.30	31.70
Household size	8.60	8.70	8.40	10.30*
SES score (0–1)	0.52	0.59	0.51*	0.25*
Knowledge score water treatment (0–8)	5.17	5.39	5.14*	4.40*
	Percentage			
	Total	Doer	NonDoer	NonDoer (open wells)
Religion				
Muslim	52.7	54.5	54.0	29.0
Catholic	17.7	15.9	19.0	13.0
Protestant	24.3	28.9	22.6	20.0
Animiste	4.9	0.3	4.1	39.0
Educational level				
No school visited	42.4	32.2	45.8	58.9
Koranic school	6.7	8.3	6.5	0.0
Primary level	20.0	22.6	18.5	23.2
Secondary level	23.7	28.2	23.1	7.1
Superior level	4.4	6.3	3.6	3.6
Literacy				
Can read and write	39.3	50.8	35.7	17.9

\*Depicts significant deviations ( $P < 0.5$ ) from the group of Doers.  
SES = socio-economic.

TABLE 3

Primary sources for drinking water for the full sample according to specific regions. Fifty-nine households (5.8%) could not be classified unambiguously due to more than one source being used

Primary source	N	Percentage				
		Total (N = 1,017)	NDJ (N = 380)	Other than NDJ (N = 614)	Bongor	
					Central (N = 119)	Peripheric (N = 115)
Pump	566	55.7	61.2	52.9	17.5	38.3
Tap	262	25.8	22.5	27.4	73.8	2.5
Open well	59	5.8	0.6	8.4	1.6	40.0
Vendor	36	3.5	8.6	1.0	0.8	0.0
Surface	35	3.4	1.2	4.6	0.8	15.0
Not classified	59	5.8	—	—	—	—
Total	1,017	100	—	—	—	—

NDJ = N'Djamena.

view partners did not state a single water treatment method. Among the persons who knew at least one method, nearly all (95%) mentioned chlorine in one of its forms (liquid, powder, or tablets). Other known methods were boiling and filtering (< 5%). A total of 304 households representing 30% of the full sample reported currently treating their drinking water (Doers). When asked for the applied method, over 95% answered that they were using chlorine products.

Differences for the primary water sources could be found between settings (Table 3). This becomes clearly visible for the town of Bongor, where both central and peripheric quarters were independently selected for the survey. Elevated percentages of users of modern pumps and piped water systems (taps), compared with traditional open wells and surface water sources for the capital city of N'Djamena, represent a higher level of development and show the importance of available infrastructure for people's options and their choice of water sources.

The traditional way of storing drinking water in homes in the region are ceramic jars placed either directly on the ground or on a rack that keep the water cool, which are routinely refilled with fresh water. Alternatively, plastic containers are used such as jerry cans or simple buckets. Water for drinking is habitually served by dipping a smaller cup into the container by hand, oftentimes making contact between the hand and the water body and thus representing a possible source of recontamination of the stored water. Although a majority (62%) of water storage containers were found covered with a lid, traces of visible dirt were found in every second (48%) container during structured household observations. In addition, the heavy weight of the ceramic jars impedes their frequent cleaning.

The second research question asked for the assessment of behavioral determinants for the future promotion of water treatment. The position of total means as well as differences in means on the standard scale were used to estimate the IPs for all psychological components of the RANAS model<sup>22</sup> for the targeted water treatment behavior, perceived vulnerability was measured using six items (Cronbach  $\alpha = 0.938$ ) asking about general, personal, and children's risks of contracting diarrheal diseases and cholera (scale range for all questionnaire items from 1 = very low to 5 = very high). On average, perceived vulnerability was rated rather low (M = 2.35; SD = 1.13). This result was equal for both Doers and NonDoers of water treatment. Severity (two items;  $\alpha = 0.863$ ), described as the consequences of contracting diarrheal diseases, was rated

as moderately severe ( $M = 3.05$ ;  $SD = 1.25$ ). Again, no great differences could be observed between groups of performers. Knowledge about risks and disease was assessed using four questions on causes, effects, treatment options, and preventative measures for diarrheal diseases. The mean score on knowledge was moderate ( $M = 2.93$ ;  $SD = 0.97$ ), again with only small differences between the groups of Doers and NonDoers. All three factor scales result in a moderate IP for this component. All results are displayed in Figure 2.

Both of the attitudinal subscales, instrumental beliefs about costs and benefits of water treatment ( $\alpha = 0.539$ , four items and  $\alpha = 0.837$ , five items, respectively), revealed rather high

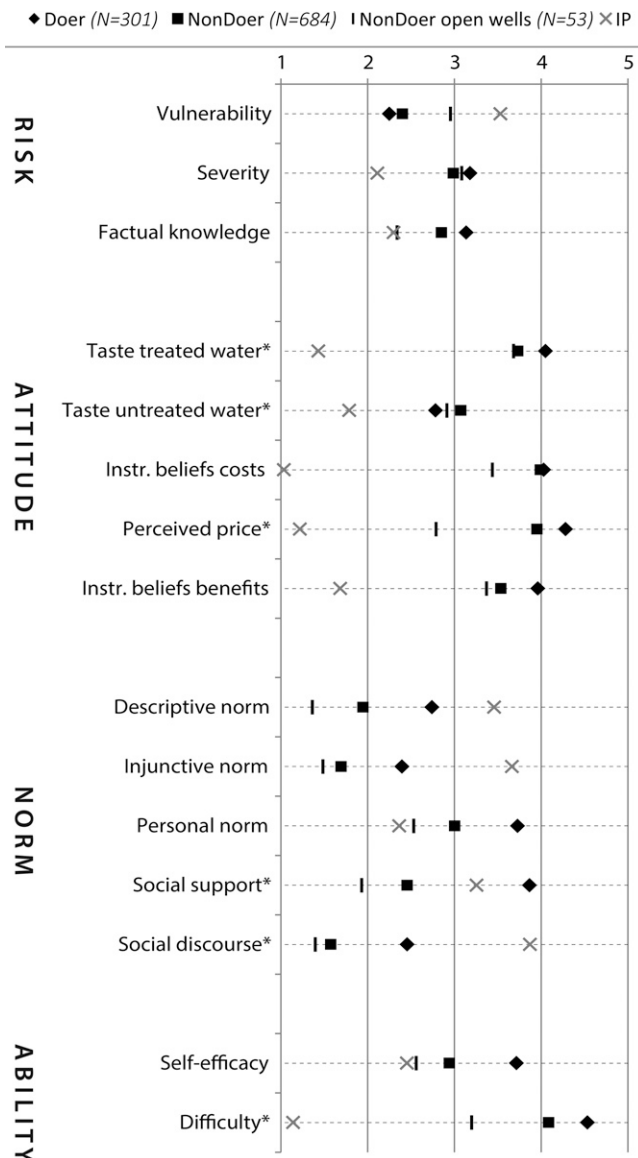


FIGURE 2. Graphical overview of the results of the RANAS (Risk, Attitude, Norm, Ability, and Self-regulation) factor analysis. Statistical means for the groups of Doers ( $N = 301$ ; diamonds) and NonDoers ( $N = 684$ ; squares), as well as for NonDoers using open wells ( $N = 53$ ; bars), as well as the intervention potential (IP; crosses) are displayed for comparison for all sub-factors. Individual questionnaire items (\*) are displayed where important differences were found between groups. Note that all items were standardized and recoded so that a high score represents a favorable result for water treatment behavior (e.g., high instrumental beliefs or low perceived price).

scores. On average, respondents generally had positive thoughts toward water treatment and did not find it very expensive or time-consuming, nor effortful (average  $M = 4.05$ ;  $SD = 0.85$ ), and its positive outcomes compared with its costs were also rated as quite beneficial (average  $M = 3.67$ ;  $SD = 0.97$ ). The taste of treated water was generally rated higher ( $M = 3.83$ ;  $SD = 0.85$ ) than that of untreated water ( $M = 2.98$ ;  $SD = 1.34$ ) by both groups. The IP for all factors within this component is therefore low.

The perception of how common water treatment behavior is seen within the communities was very low (descriptive norm;  $M = 2.19$ ;  $SD = 1.00$ ;  $\alpha = 0.816$ ; two items). The injunctive norm factor showed equally low values ( $M = 2.21$ ;  $SD = 1.00$ ;  $\alpha = 0.609$ ; three items), representing people's experiences of how strongly water treatment is promoted by important persons such as state and religious authorities. However, the personal norm factor (how important water treatment is rated personally) was higher, with a medium scale average ( $M = 3.23$ ;  $SD = 1.02$ ;  $\alpha = 0.547$ ; two items). The two items on social discourse about water treatment ( $M = 2.88$ ;  $SD = 1.54$ ) and social support supplied by the head of household to the primary caregiver in performing it ( $M = 1.48$ ;  $SD = 1.21$ ) also showed moderate to low overall means, as well as large differences between Doers and NonDoers of up to 1.4 scale points. All norm factors showed significantly higher values for the group of Doers. Normative factors therefore reveal a moderate to high IP, both from an overall means perspective and from differences between groups of performers.

Ability factors, measuring people's perceptions of their own skills to pick up and maintain water treatment behaviors and to recover from drawbacks (self-efficacy), were found to score in the medium range ( $M = 2.97$ ;  $SD = 1.12$ ;  $\alpha = 0.890$ ; five items). Differences of 0.8 scale points between groups of performers depict a moderate IP.

Self-regulation factors (not shown in Figure 2) were only assessed for the group of Doers, since questions about action-control of, and the level of habituation to, an existing behavior only make sense to people already performing this behavior. Therefore, to assess the predictive power of self-regulation factors for water treatment behavior, differences were calculated within the group of Doers between those who expressed high-, mid- and low-habituation water treatment behavior (generated from three items on habituation). While the average among all Doers for action-control ( $M = 3.57$ ;  $SD = 1.09$ ;  $\alpha = 0.723$ ; two items) and commitment ( $M = 3.94$ ;  $SD = 0.68$ ;  $\alpha = 0.644$ ; four items) was generally high, moderate differences between groups of performers point toward possible IP.

**Subgroup analysis.** To address the third research question about special groups of interest, the sample has been divided into subgroups depending on sociodemographic and technological factors. Differences in water treatment behavior could be found between regions, comparing the city districts of N'Djamena (35.5% Doers) with the remaining sample (27.8%) and more so between the urban (26.4%) and rural (11.7%) quarters of Bongor. However, the lowest rate of water treatment (5.1%) was found for the group of open-well users currently not performing water treatment (Figure 2; "NonDoers open wells"). Further investigation of this subgroup was subsequently run. Generally, this subgroup was represented more strongly within the rural study sites, where the population lives in a more traditional and oftentimes poorer or less-developed environment. Manual or electronic protected water

pumps are found less often in these areas than along the major roads and more densely populated urban sites.

Concerning sociodemographic variables, the subgroup of open-well users currently not performing water treatment also showed lower levels of education, lower literacy rates, lower socioeconomic status, larger household size, and lower scores on the knowledge test on water treatment (Table 2). Differences in psychological factors for water treatment behavior are displayed in Figure 2. Perceived vulnerability was rated higher by this group, representing a stronger concern for personal health threats from diarrheal diseases, which were rated as severe by this group as they were by the rest of the sample. All other factors showed lower scores for the group of traditional-well users, revealing a less favorable mindset for water treatment behavior than the rest of the sample. Extremely lower scores for this subgroup were found in the items of perceived price (attitude) and difficulty (ability) of water treatment (Figure 2).

## DISCUSSION

A cross-sectional survey using standardized structured questionnaires based on the RANAS model was applied to a sample population of over 1,000 households within the Lake Chad region, to assess psychological determinants and technological factors for water treatment behaviors.

Water treatment methods, mostly chlorine products, were used by about one-third (30%) of the studied population. This low rate matches findings from focus group discussions and anecdotal information that people only add chlorine to their drinking water in times of current cholera outbreaks and do not see the necessity of constant application. Two knowledge tests within the questionnaire revealed moderate to low levels of understanding about the causes and symptoms of treatment, and preventative measures against diarrheal diseases. Knowledge of water treatment methods was also low to nonexistent within a great proportion of people living in the study area: over half of the interviewed persons could not name a single measure to disinfect drinking water.

Important findings for making an evidence-based decision on the choice of BCTs to promote household water treatment came from the analysis of psychological determinants, people's thoughts and attitudes concerning the application of treatment methods expressed in the interviews.

Respondents did not see themselves at high risk for diarrheal diseases, including cholera, despite the high prevalence of diarrhea in the study population. Because of the fact that no cholera cases had officially been observed in the study region in the 2 years prior to the survey,<sup>41</sup> it did not make sense to assess short-term cholera prevalence. When asked about all diarrhea cases within the previous week (a 7-day recall period), 43% of all households reported at least one episode, almost always affecting a child under the age of 5 years. This discrepancy might be explained by the fact that despite this high self-reported prevalence, over half of the interviewees were rather or completely satisfied with the current health situation of their families, and not or only a little anxious about their future health situation. Although symptoms of diarrhea are generally known, the perception of their severity is only rated as moderately severe on average. It appears that health problems, especially related to diarrhea, are not seen as highly relevant problems despite their omni-

presence and recurring episodes of cholera with high death tolls in the country. Together with the low level of knowledge displayed about disease and preventative measures, the low overall perceived vulnerability results in an important IP for the risk factors. Thus, strategies to sensitize the population to existing health risks and inform them about water treatment technologies, combined with instructions on how to apply them, should be considered in the design of an intervention campaign.

High average values for the attitudinal factors, in combination with small differences between groups of performers, result in only a small IP for this component. Therefore, no specific strategies will be proposed. In addition, the groups of Doers and NonDoers both reported preferring the taste of treated water and rated it higher than the taste of untreated water. This is especially important for the promotion of chlorine, since it can strongly affect the taste of water.

The highest IP could be found for the norm component, addressing normative perceptions about how well-established water treatment is within communities, how much it is promoted, and how important it is seen personally. The lowest mean values were found for all subscales of this psychological component, as well as for individual items asking about social support and normative discourse. Large differences between Doers and NonDoers in norm factors undermine this. This finding can be directly linked to the low rate of performers (30%), which makes it understandable that the perception of existing water treatment within communities is higher where it is seen more often. People who already perform water treatment seem to experience higher social norms, social acceptance, and even social pressure for, and discourse about, doing it. Normative factors therefore seem to play an important role in the formation of water treatment behaviors and the establishment of habits, and should therefore be addressed using corresponding BCTs to encourage their uptake and maintenance.

Ability factors revealed moderate IP; in particular, the lower perceived self-efficacy in performing water treatment among the NonDoers compared with the Doers speaks for the inclusion of a corresponding BCT. NonDoers could be persuaded to start water treatment when equipped with the necessary knowledge (see above) and the required skills and demonstration of performance, leading to an elevated perception of self-efficacy.

By looking for distinct subsamples and potentially disadvantaged groups, we found water treatment behaviors to be significantly lower within the group of traditional-well users, of whom only 5% reported current water treatment compared with the overall rate of 30%. This finding reflects the decrease in water treatment behaviors that could already be observed between more urban and rural areas within the town of Bongor, but is still extremely low. Detailed analysis revealed that knowledge about disease and prevention was also much lower in this group.

Traditional-well users (95% of whom are NonDoers) also showed significant differences (see Figure 2) in other psychological determinants for water treatment, which in turn calls for adapted intervention strategies specifically tailored for this subpopulation. Higher scores in this subgroup than in all other groups could be found for the factor of vulnerability. At first glance, this is surprising when compared with the low rate of water treatment found for this group. One would probably

expect a rather higher behavioral rate. However, the low rate of water treatment could explain the higher risk perception, because these individuals know that they almost entirely do not treat their drinking water, they might be aware of their higher risk. The consequences of diarrhea were rated equally as severe by this subgroup as by the rest of the sample, which once again underscores the distinct difference in vulnerability. All other results were generally lower but revealed a similar perspective for the design of intervention strategies. From an intervention perspective, the results revealed higher considerable IPs for the same factors as for the full sample reported earlier. Extremely lower scores in the subgroup were found for the items of perceived price (attitude) and difficulty (ability) of water treatment, which would require additional intervention elements. BCTs aiming at changing price perception and at fostering expected self-efficacy would be appropriate means to tackle these factors.

Looking at sociodemographic and economic variables, this subgroup on average showed both lower levels of education and lower socioeconomic scores based on household possessions. The users of traditional wells participating in this study could thus represent a potentially disadvantaged, generally poorer group that also lives in poorer sanitary conditions in rural settings. Special attention might need to be paid to this group, since the poorest of the poor often go unserved, and equality issues have increasingly been raised within development projects.<sup>33</sup> Adding supplementary strategic elements to a behavior change campaign, however, will always add to the costs and will strain the available resources. The small proportion of traditional-well users within the full sample (~6%) will raise the question of cost-effectiveness and should be carefully discussed before taking action. In addition, this group will profit from the general strategies proposed.

**Implications for practice.** The results will be shared with all project stakeholders, namely the WHO headquarters and country office in Chad, the Ministry of Public Health in Chad, and the CSSI, the local NGO in charge of the field work, to discuss plans for further precipitation of the development of intervention strategies. To foster the adoption and maintenance of water treatment at the household level, we propose several BCTs to be applied, according to the guidelines derived from experience in several projects in developing countries.<sup>30</sup>

Personal risk perception, social norms as well as encouragement by the authorities and influential persons, and perceived self-efficacy have been found to be the most important factors affecting water treatment behaviors within the local context.

In particular, the two factors of descriptive and injunctive norm perceptions revealed the greatest differences between performers and nonperformers of water treatment, thus showing their importance for the promotion of this behavior within the study population. The importance of normative factors for the promotion and adoption of key WASH behaviors has been demonstrated in several other projects in developing countries, and commitment-enhancing behavior change strategies for safe water consumption have been successfully implemented. Basic effects can also be expected from standard information BCTs.<sup>41–43</sup>

Based on these results, we propose a 2-fold strategy in the given setting for the promotion of water treatment using chlorine, drawing on a combination of several BCTs. To target personal risk perceptions, information about sources of contamination, the role of water (especially household water

stored for consumption) in disease pathways, and the preventative role of water treatment against diarrheal diseases should be diffused. As radio seems to be the most common mass media communication channel, most of the intervention messages could be delivered this way. In addition, we propose testing the supplementary effects of community meetings, where normative elements can be reinforced by inviting local authorities to attend and to publicly announce their approval. By giving a demonstration of how to apply chlorine together with information about where to buy it, sources of self-efficacy, one of the key components for behavior change, will be activated, addressing the ability factor.<sup>44</sup> Personal norms and commitment toward water treatment can be further strengthened by asking for a public pledge, which is effective in two ways. First, because this pledge is done in public, normative factors are again addressed. Second, people will be given signs to place on the outside of their houses to show all passersby that “more and more” people are engaged, thus changing descriptive norms. For the public commitment, we suggest inviting not only the primary caregivers responsible for water treatment but also the heads of households. Since support by the household’s head (male in 95% of cases) showed such a high IP and they are responsible for the purchase of chlorine, their commitment should have a strong but distinct effect on a caregiver’s commitment, but this will not have any impact as long as technological means are not available.

**Limitations of this study.** Self-reported measures are always subject to bias due to social desirability and comprehension issues, especially in multinational and multicultural settings. However, the large sample size and planned longitudinal design of the complete study program allow us to deal with this issue by comparing only differences between intervention groups, thus controlling for these effects.

Currently, we only dispose of cross-sectional data to assess psychological factors and the design of intervention strategies for behavior change; however, longitudinal data will be necessary to 1) confirm the correctness and stability of these findings and 2) evaluate their correctness by measuring the effects of those strategies on actual behavior change. In addition, these findings are always bound to the local context; therefore, the question of generalizability for larger intervention areas might be limited and should always be accompanied by additional surveys prior to the application of BCTs. Different environments and the sociocultural compositions of local populations can vary even within one country, in terms of needs and psychological structures. Consequently, applied intervention strategies should always be developed in a population-tailored manner to match the particular characteristics.

## CONCLUSION

For the first time, a structured and representative survey on behavioral determinants for water treatment behavior has been applied to a region at high risk for cholera in Chad. This approach allows for informed and evidence-based decision making on appropriate intervention strategies to support the government of Chad in its efforts to fight and control cholera and other diarrheal diseases. Tailored intervention strategies for the masses can also be designed based on these findings, addressing exactly those psychological factors that have been shown to be of high importance for the adoption and maintenance of water treatment behaviors within the local study



population. In addition, important subgroups with specific characteristics have been identified, revealing special needs that should receive additional attention. Risk perception, social norms, and perceived self-efficacy have been identified as the strongest predictors for behavior changes concerning water treatment in western Chad, and should therefore be addressed in future efforts for its promotion.

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